Matching Methods for Causal Inference

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Microsoft Research, 1/19/2018

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3 Problems, 3 Solutions

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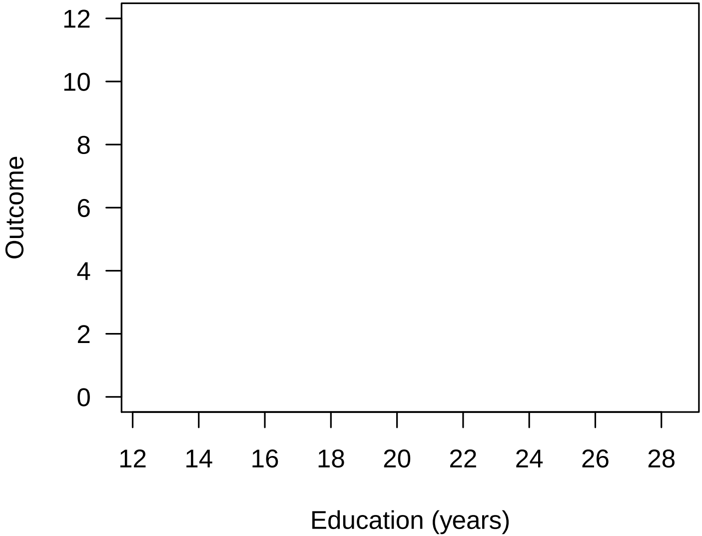

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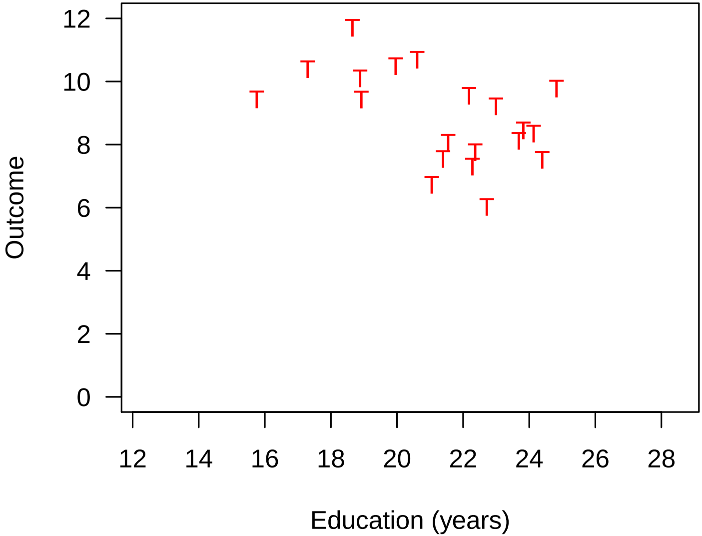

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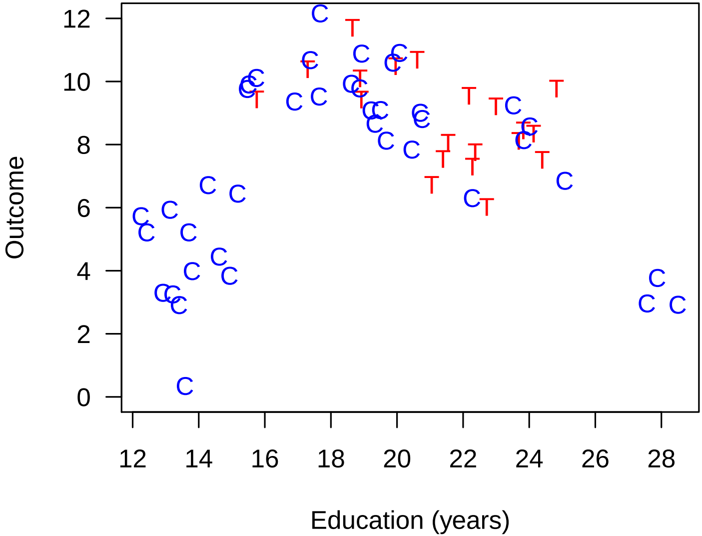

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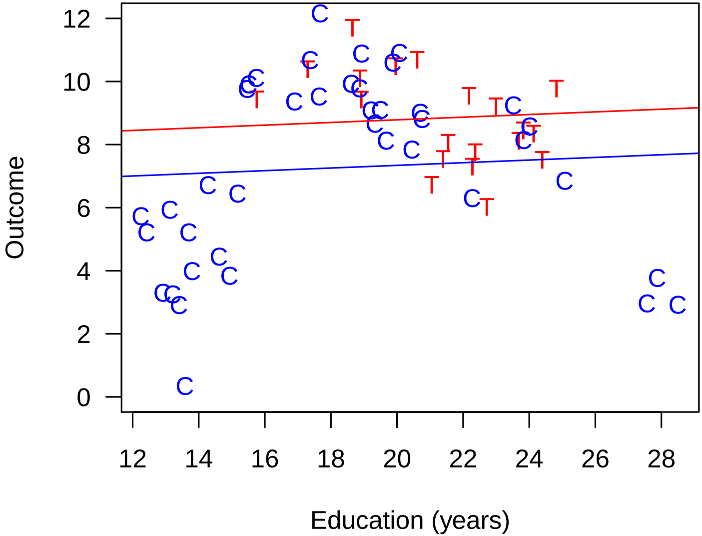

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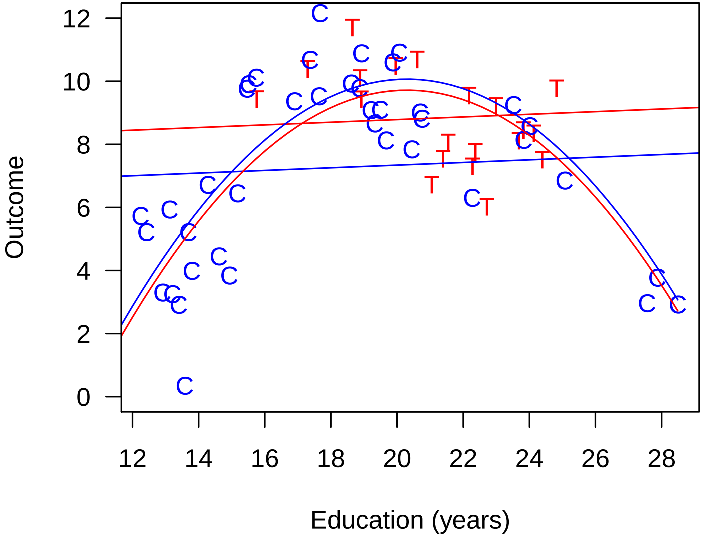

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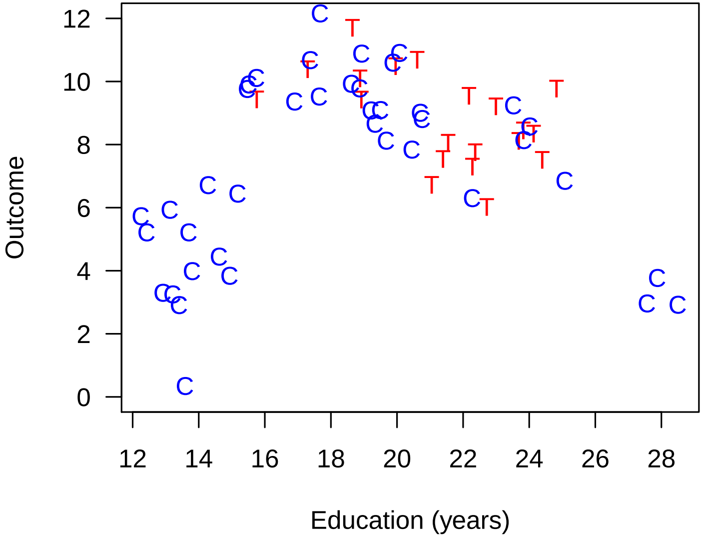

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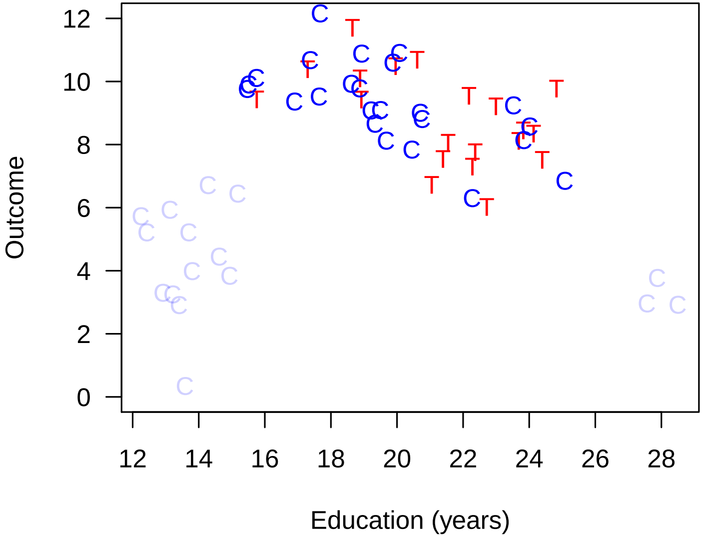

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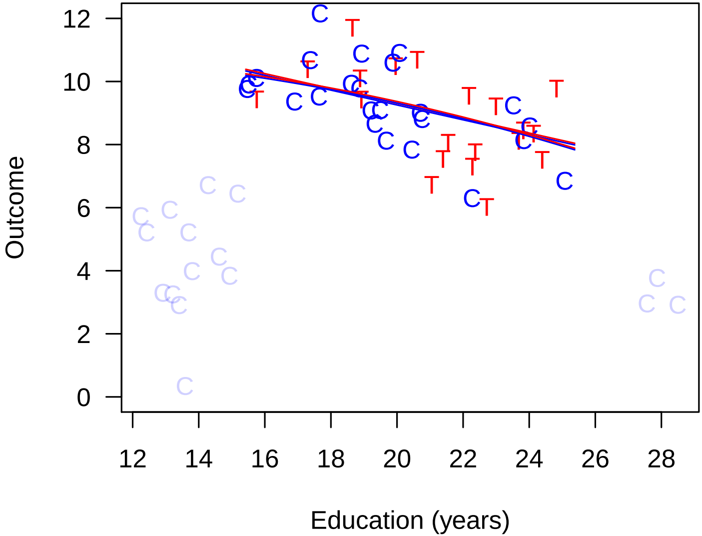

The Problems Matching Solves

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- "Teaching psychology is mostly a waste of time" (Kahneman 2011)

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A central project of statistics: Automating away human discretion

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- Pruning nonmatches makes control vars matter less: reduces imbalance, model dependence, researcher discretion, & bias

Matching: Finding Hidden Randomized Experiments

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Types of Experiments

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- Other methods: *fully blocked*
- Other matching methods dominate PSM (wait, it gets worse)

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   - (Many adjustments available to this basic method)
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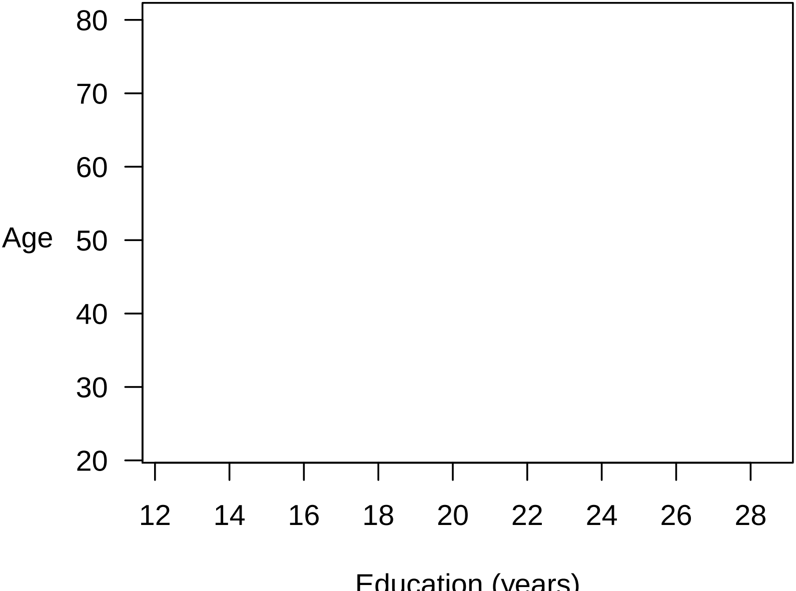

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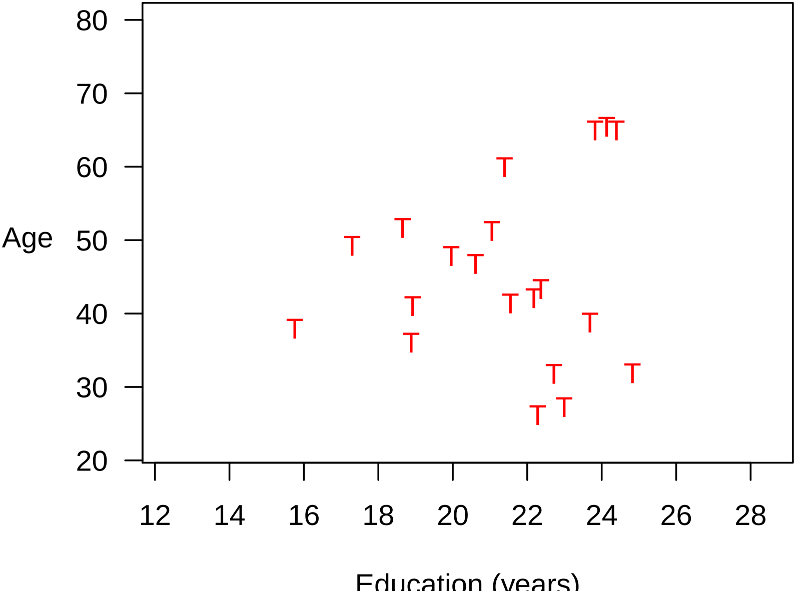

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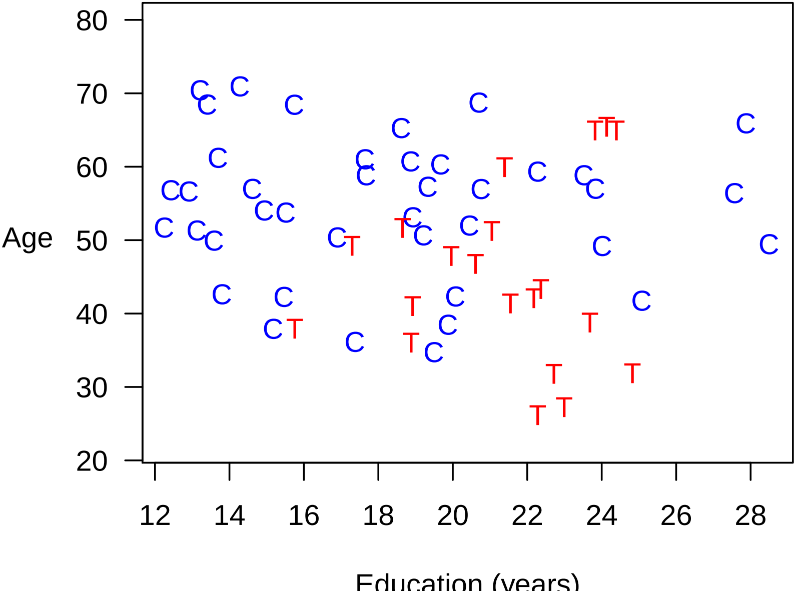

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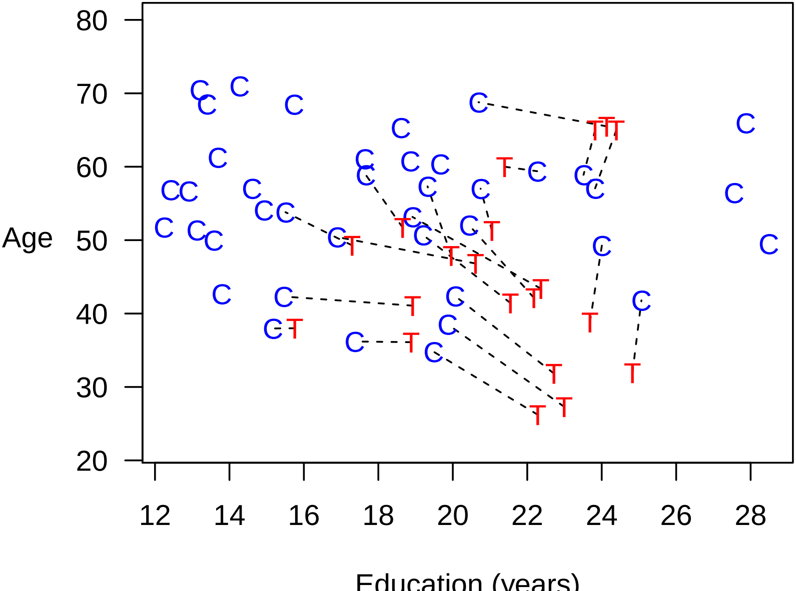

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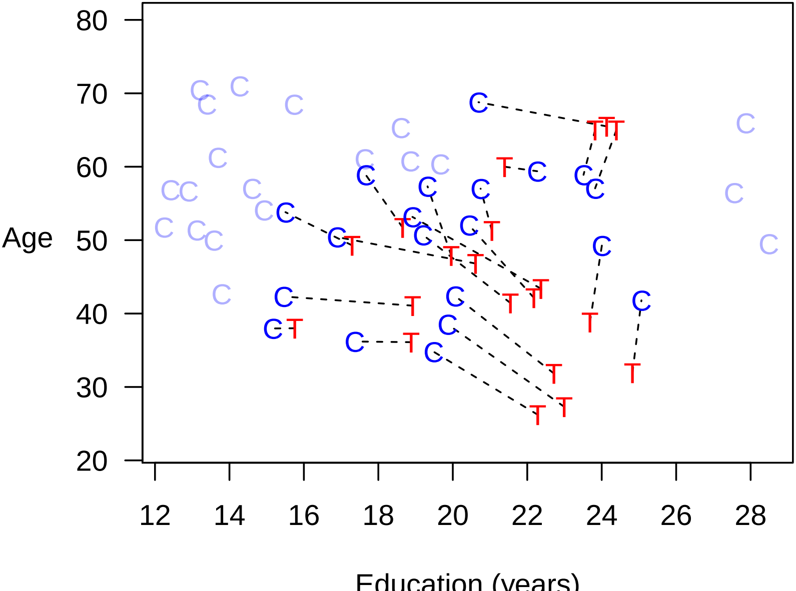

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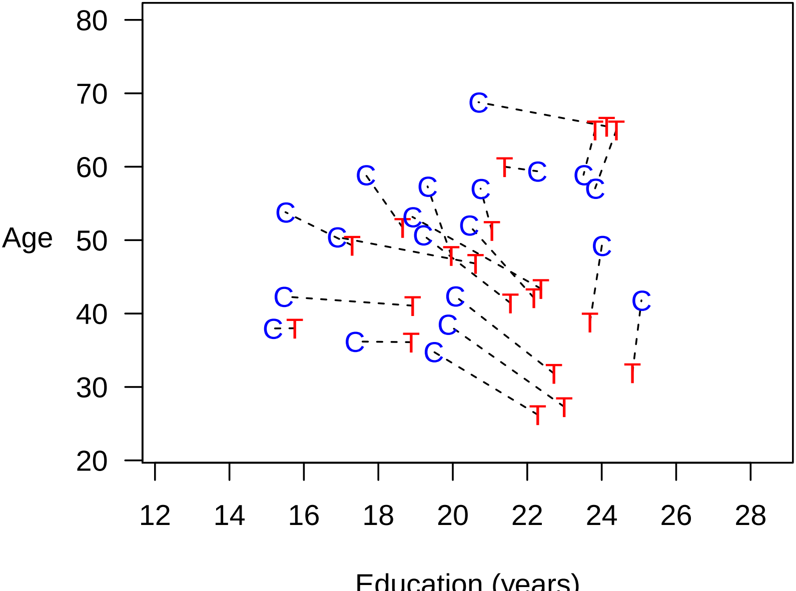

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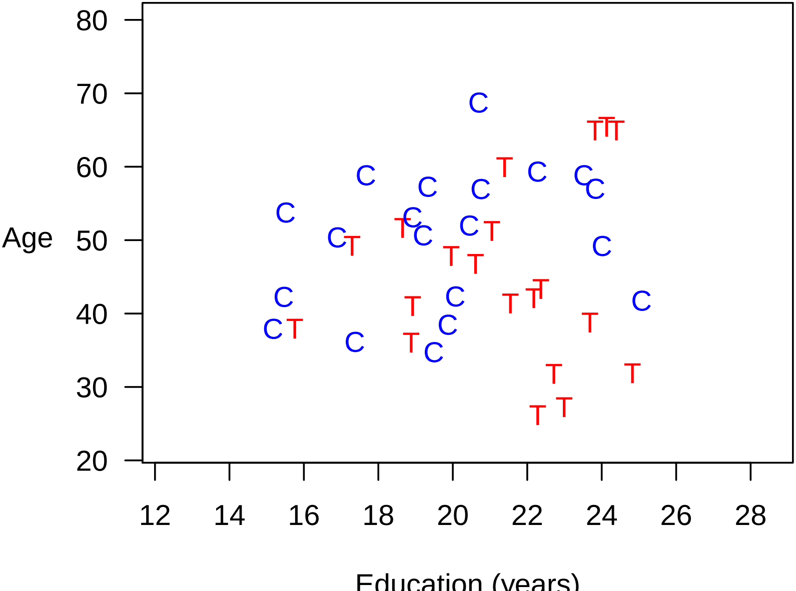

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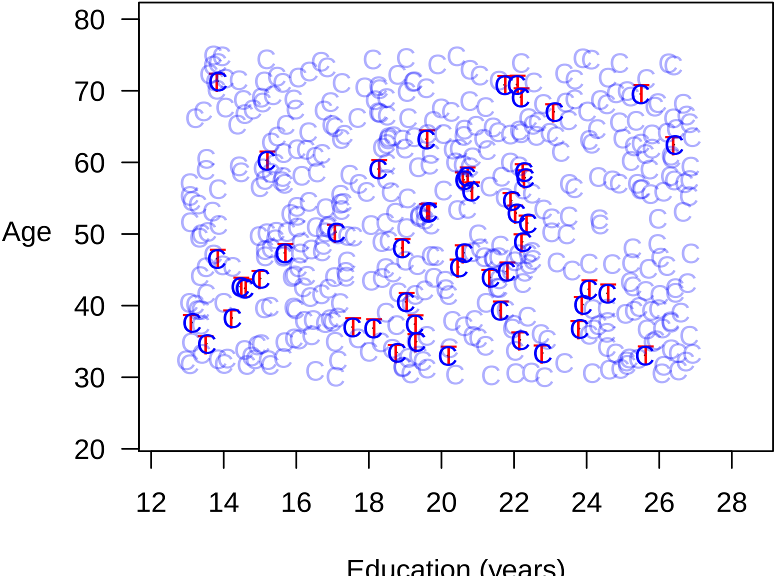

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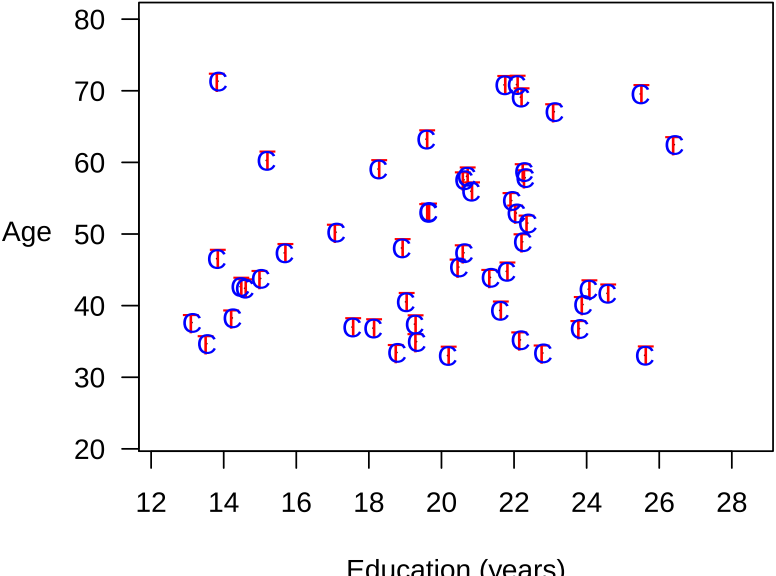

Method 2: Coarsened Exact Matching (Most powerful easy-to-use approach)

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(Approximates Fully Blocked Experiment)

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1. Preprocess (Matching)

2. Estimation Difference in means or a model

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   - Temporarily coarsen X as much as you're willing

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   - Weight controls in each stratum to equal treateds

Coarsened Exact Matching

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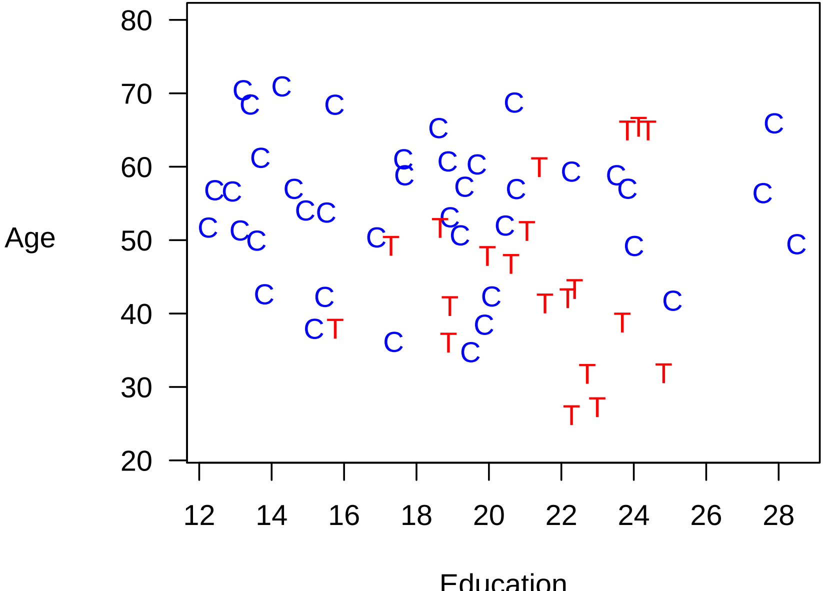

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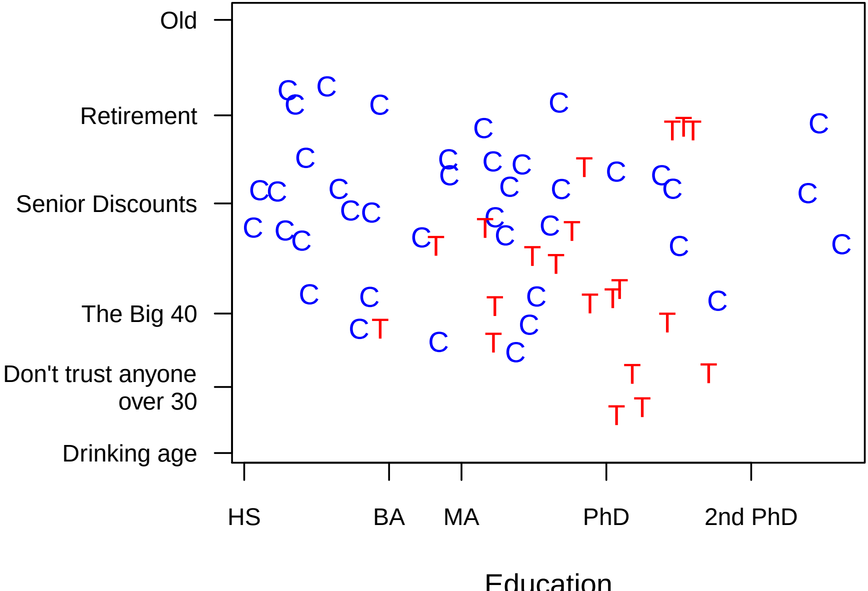

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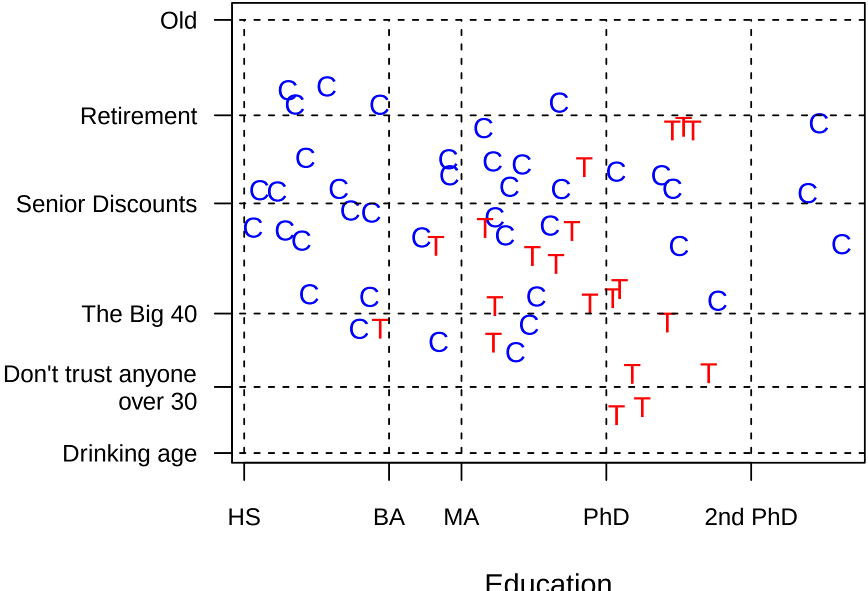

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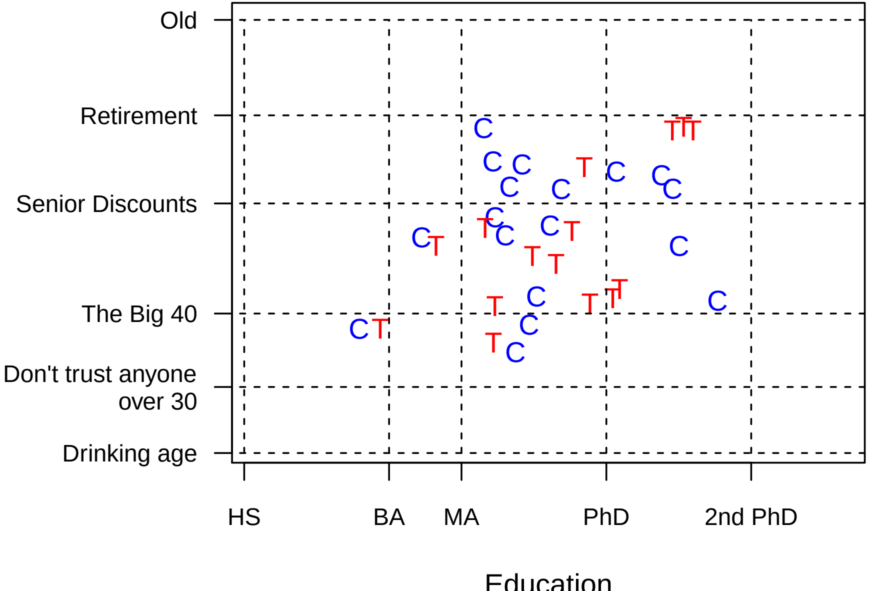

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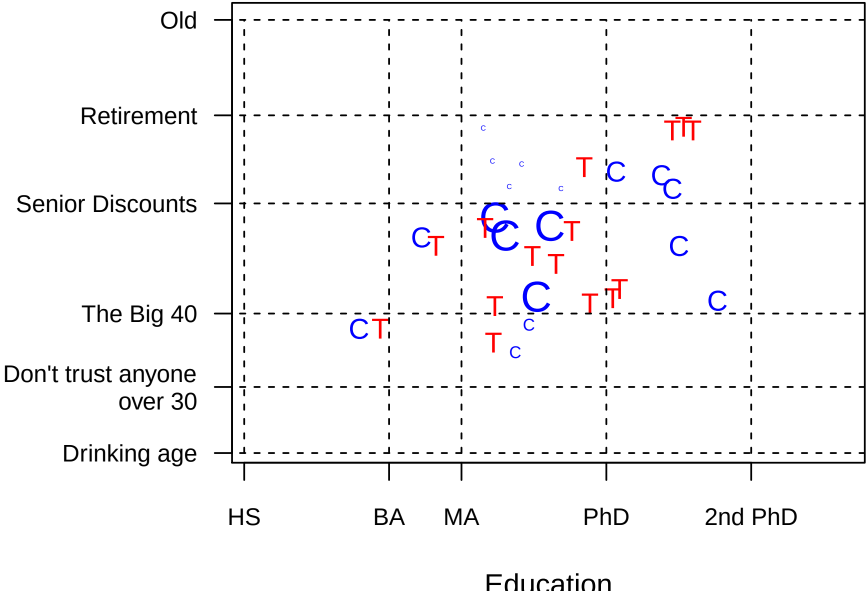

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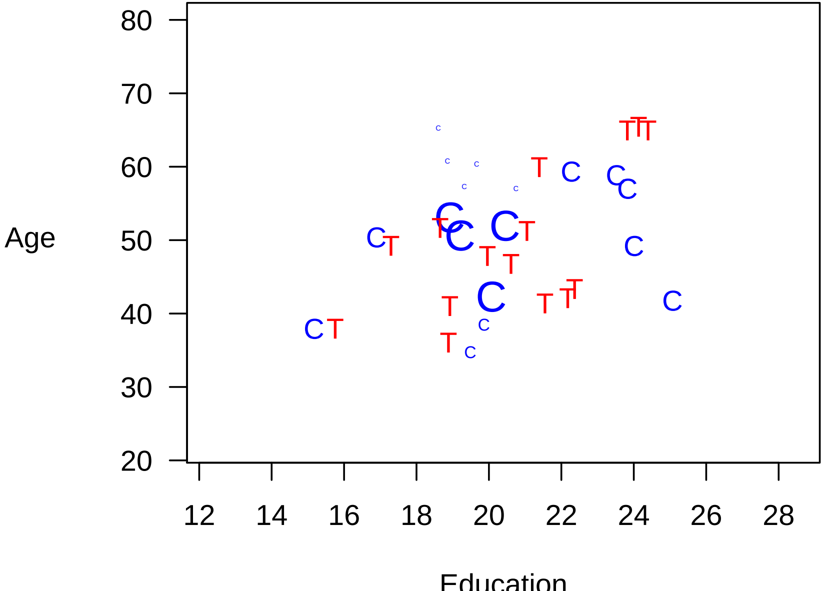

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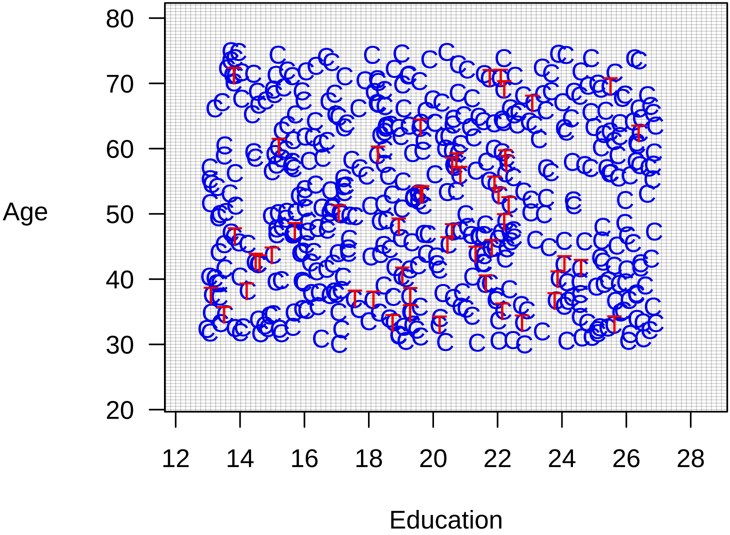

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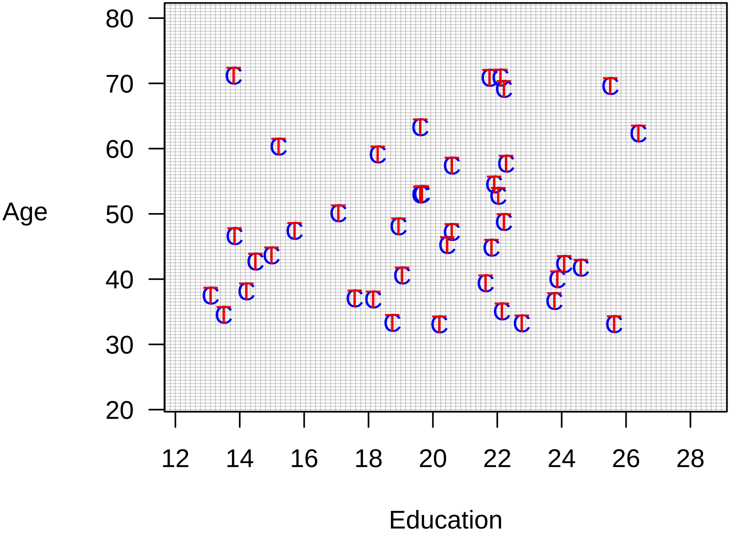

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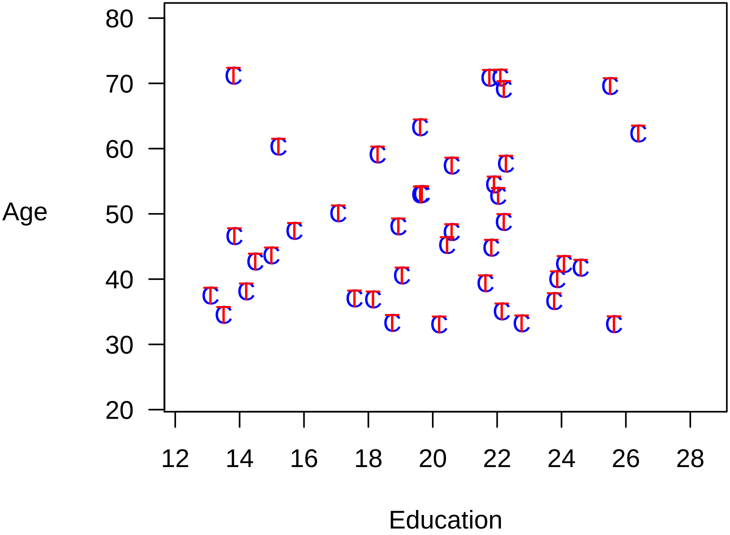

Method 3: Propensity Score Matching

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1. Preprocess (Matching)
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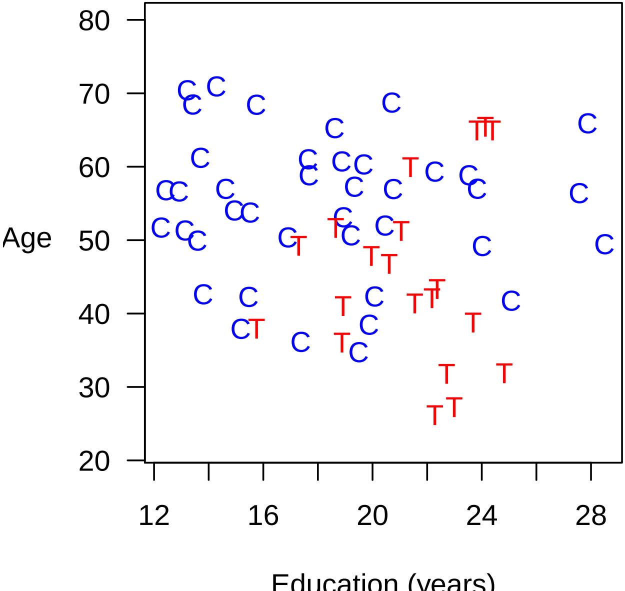
    - (Many adjustments available to this basic method)
2. Estimation Difference in means or a model

Propensity Score Matching



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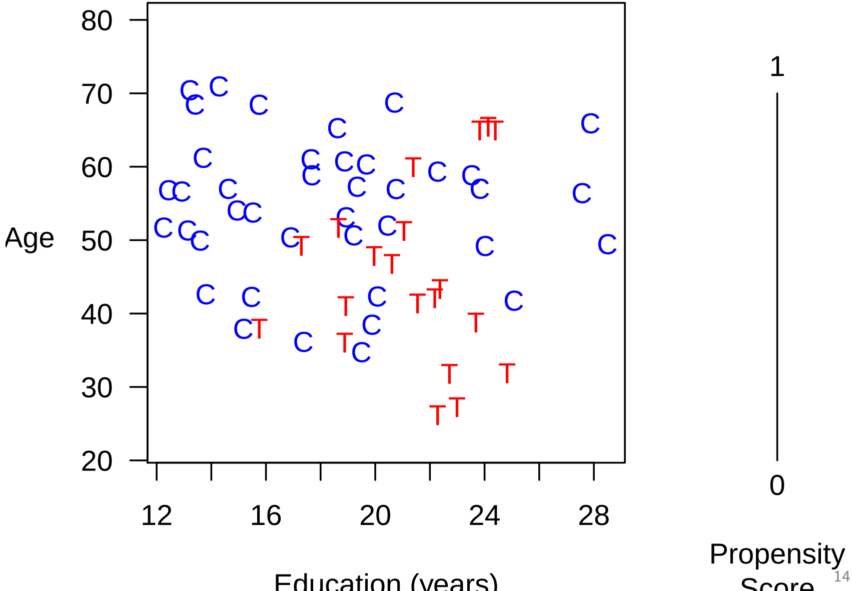

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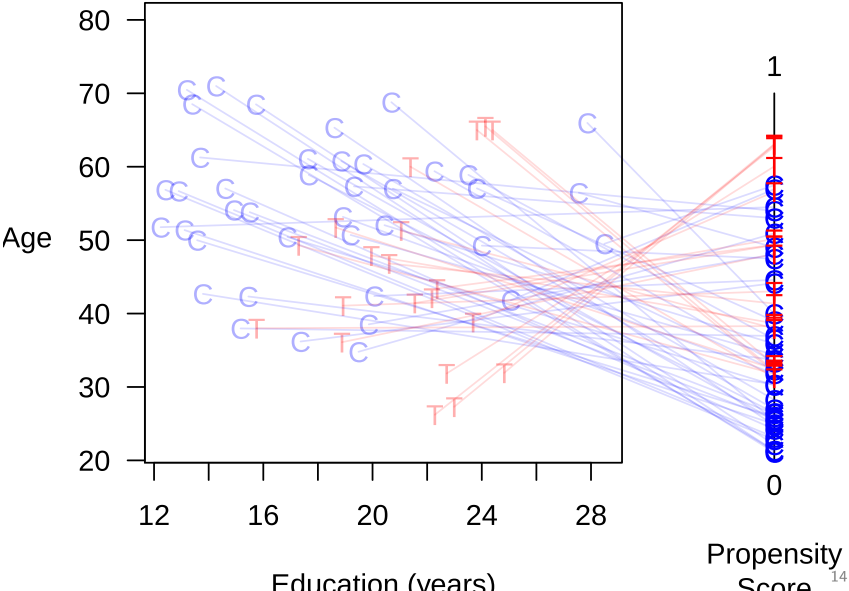

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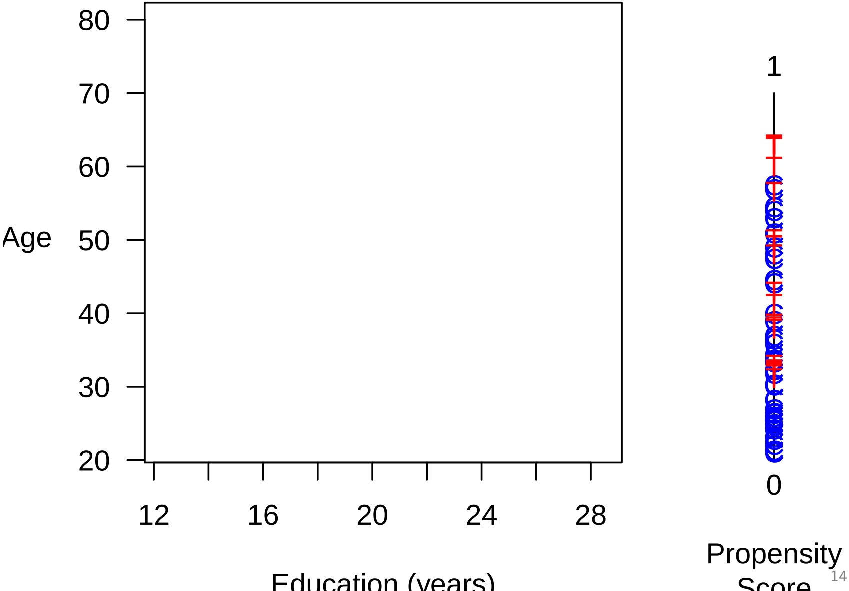

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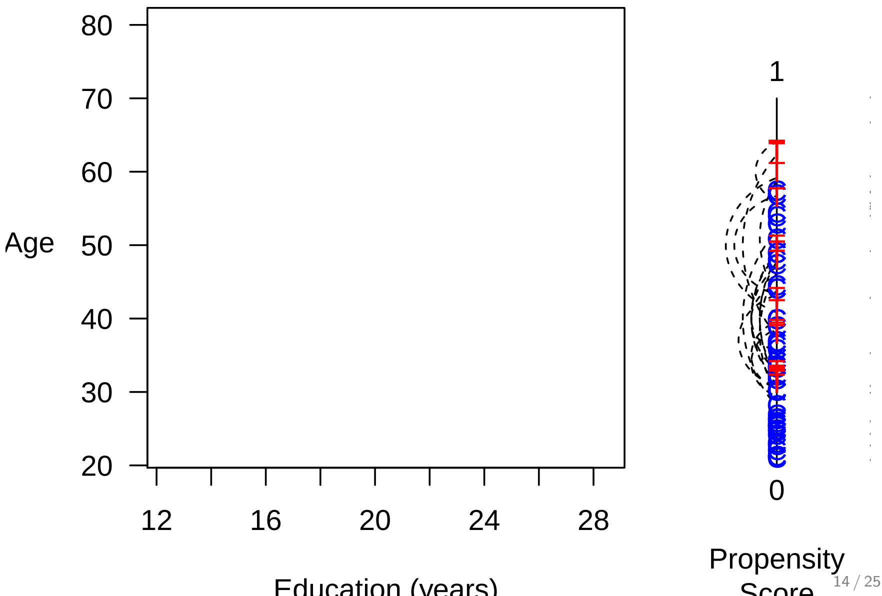

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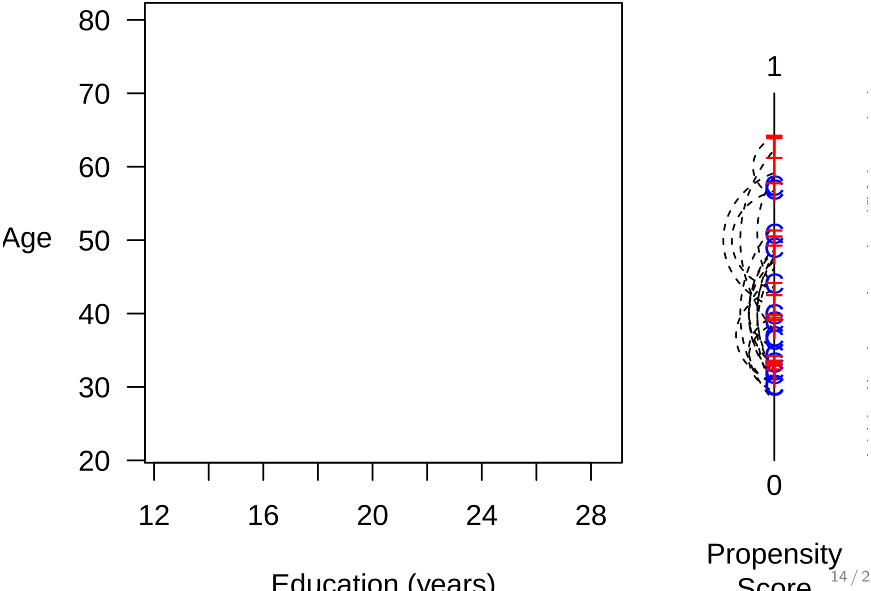

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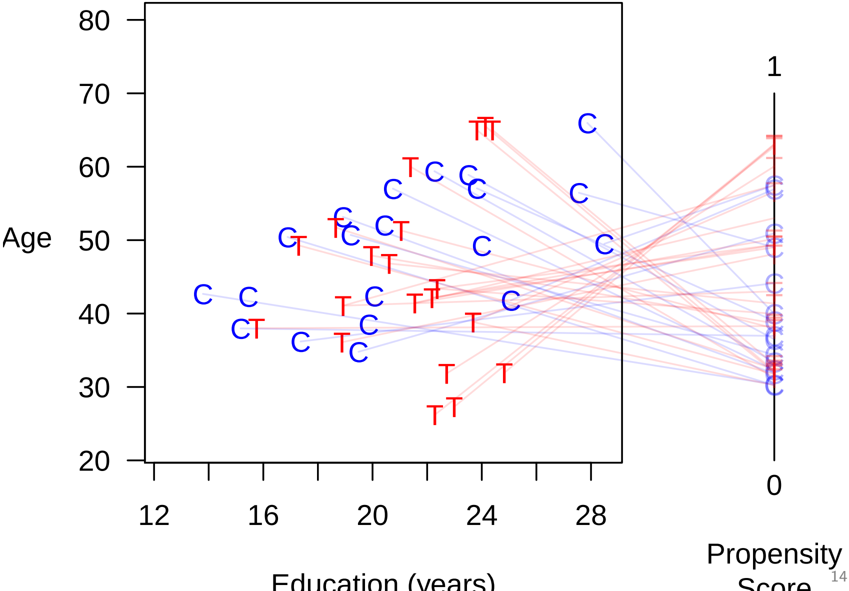

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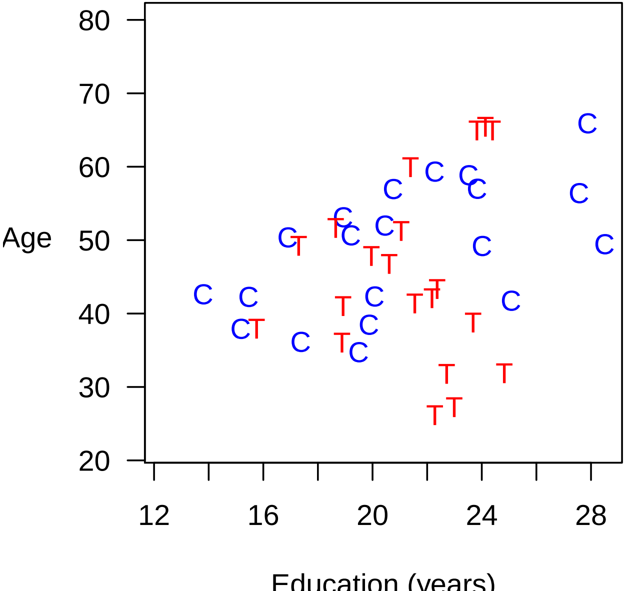

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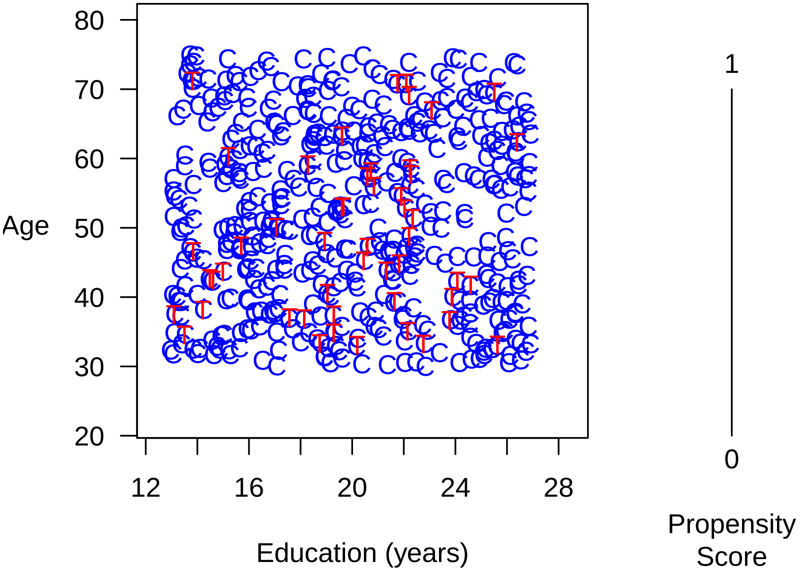

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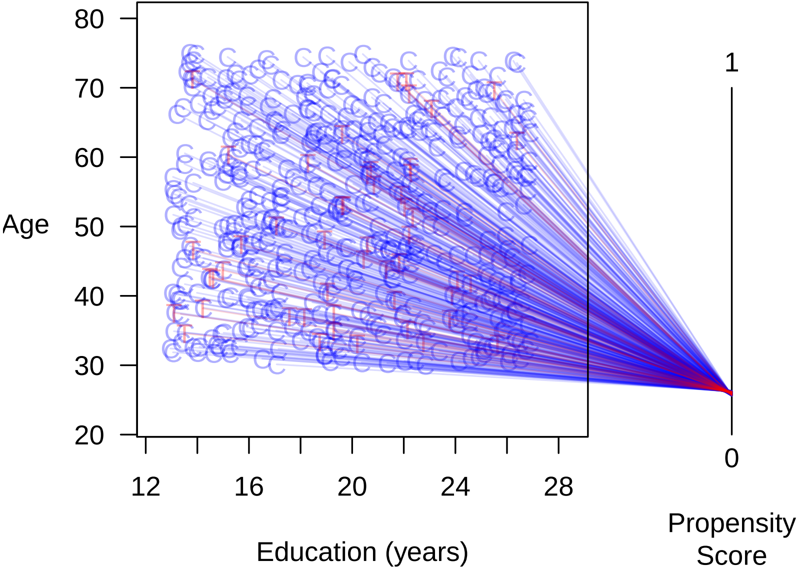

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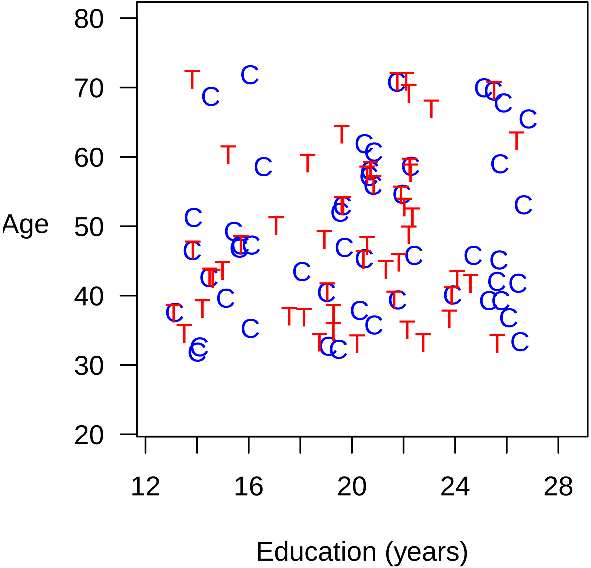
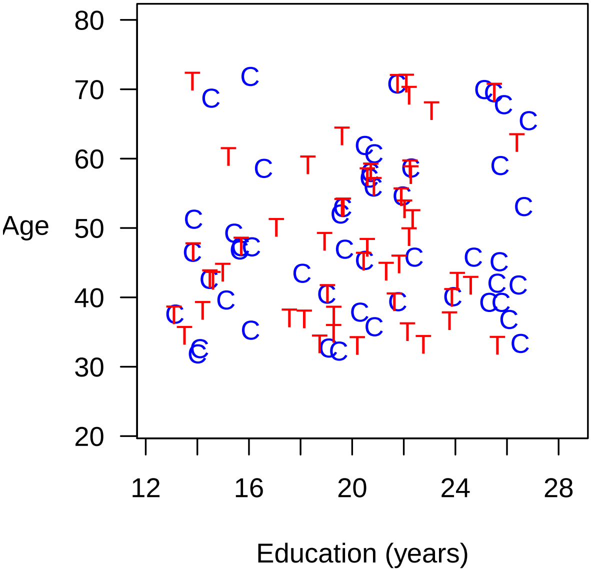


Best Case: Propensity Score Matching is Suboptimal



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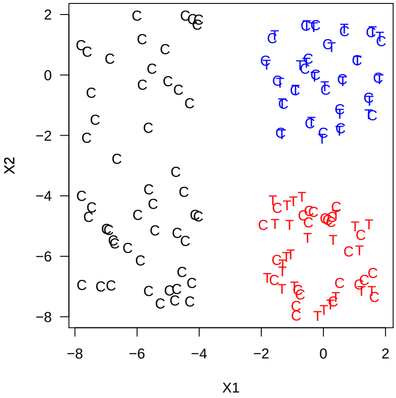

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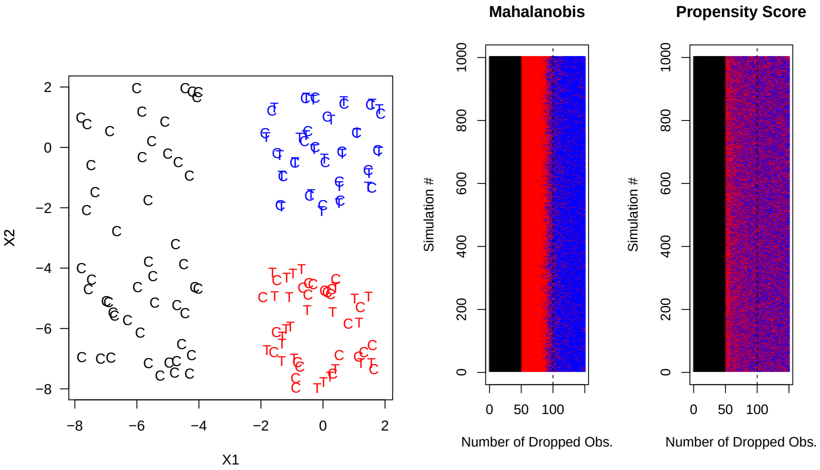
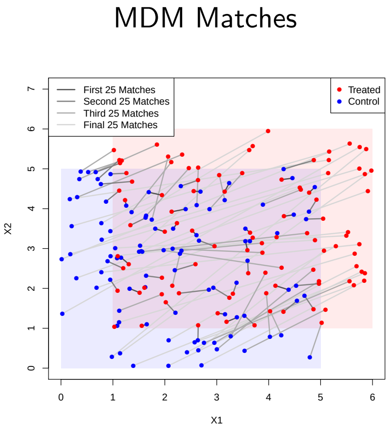
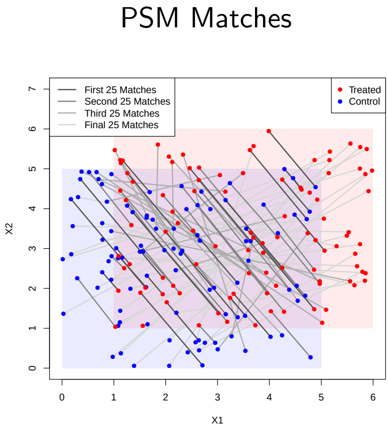


What Does PSM Match?



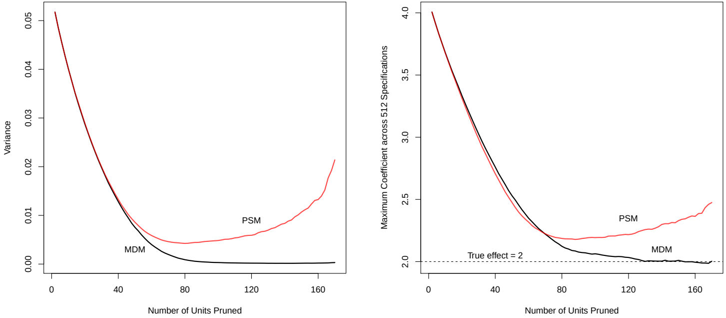


Controls: $X_1, X_2 \sim \text{Uniform}(0,5)$
Treateds: $X_1, X_2 \sim \text{Uniform}(1,6)$

PSM Increases Model Dependence & Bias

Model Dependence

Bias



$$Y_i = 2T_i + X_{1i} + X_{2i} + \epsilon_i$$
$$\epsilon_i \sim N(0,1)$$

The Propensity Score Paradox in Real Data

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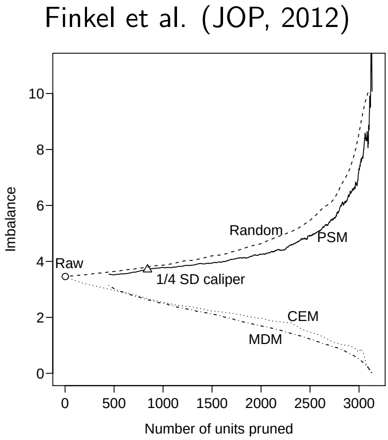
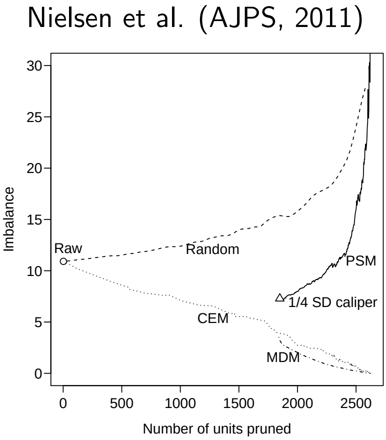
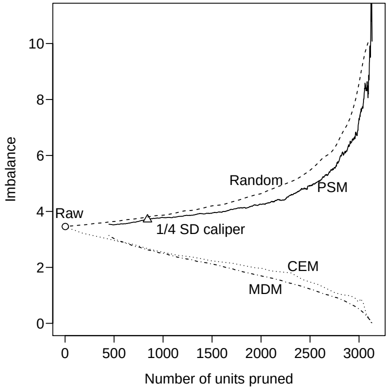


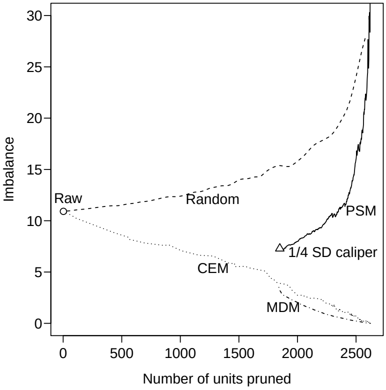


The Propensity Score Paradox in Real Data

Finkel et al. (JOP, 2012)



Nielsen et al. (AJPS, 2011)



Similar pattern for $>$ 20 other real data sets we checked

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- Choose an imbalance metric, then run.

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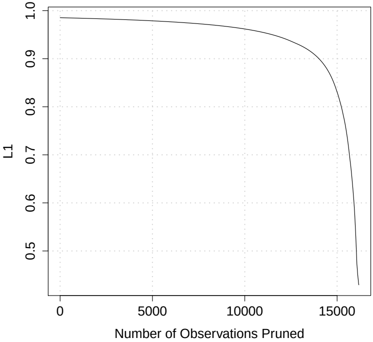
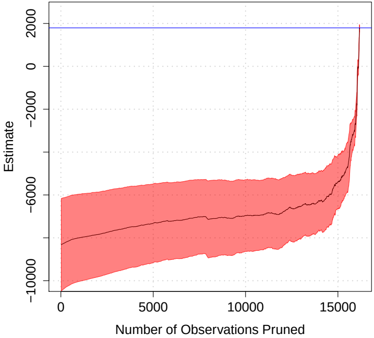
Job Training Data: Frontier and Causal Estimates





- 185 Ts; pruning most 16,252 Cs won't increase variance much
- Huge bias-variance trade-off after pruning most Cs
- Estimates converge to experiment after removing bias
- No mysteries: basis of inference clearly revealed

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For more information, articles, & software

GaryKing.org